DETERMINATION OF MICROPLASTICS IN SURFACE WATER FROM IKPOBA RIVER, BENIN CITY, NIGERIA.

BY

NNABURU BENEDICT CHIDUMEBI (MR)

LSC2006941

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AN UNDERGRADUATE DISSERTATION SUBMITTED TO THE DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA; IN PARTIAL FUFILMENT OF THE REQUIREMENTS FOR AWARD OF BACHELOR OF SCIENCE (B.Sc) DEGREE IN ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY

NOVEMBER, 2025.

CERTIFICATION

This is to certify that this research titled "**DETERMINATION OF MICROPLASTICS IN SURFACE WATER FROM IKPOBA RIVER, BENIN CITY, NIGERIA**" was carried out by **"NNABURU BENEDICT CHIDUMEBI (MR)**" and presented to the Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, Benin City: in partial fulfillment of the requirements for the award of Bachelor Science (B.Sc) in Environmental Management and Toxicology. It was conducted under suitable conditions, was carefully supervised and subsequently approved as having met the requirements for the award of a Bachelor of Science degree in Environmental Management and Toxicology.

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DR. (MRS.) I. E. IYORAH-ELLIOT **DATE**

(PROJECT SUPERVISOR)

…………………………….. ……………………………..

PROF. (MRS) E. T. AISIEN **DATE**

(HEAD OF DEPARTMENT)

DECLARATION

I "**NNABURU BENEDICT CHIDUMEBI (MR)**" declare that "**DETERMINATION OF MICROPLASTICS IN SURFACE WATER FROM IKPOBA RIVER, BENIN CITY, NIGERIA**" is my work and that all sources that I have used or quoted have been acknowledged using complete references and that this work has not been submitted before for any other degree at any other university.

……………………………………… ….……………………

NNABURU BENEDICT CHIDUMEBI **DATE**

DEDICATION

This report is dedicated to God Almighty, whose wisdom, strength, and grace have guided me during this project. I also want to use this opportunity to dedicate this report to my family for playing a huge role in my academic journey through their encouragement, support and love.

ACKNOWLEDEMENT

I appreciate God's gift of wisdom, courage and diligence in allowing me to complete this project. Thank you to Dr. (Mrs.) I.E. Iyorah-Elliot for your ongoing guidance and inspiration. I would like to thank the entire staff and faculty of the Department of Environmental Management and Toxicology at the University of Benin for their knowledge and time. I would like to say thank you to my family. They've really been so helpful through their sacrifices, patience and love. And it has really helped me know that every step forward, regardless of how small it may be, is a step in the right direction. Thank you to my friends and fellow students who were there for me when I needed them, supported me, and made those long and difficult days easier. I would also like to say thank you to everyone else who has assisted me along the way. I will never forget the kindness you have shown to me.

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ABSTRACT

The hazards that microplastic pollution have incurred ecologically has made it a key environmental concern. This study determined the occurrences of microplastics in the surface water taken from Ikpoba River in Benin City, Nigeria. A total of thirty (N=30) water samples were obtained from the period of August to September 2025. The samples were collected in glass bottles from both upstream and downstream areas of the river and then tested in the laboratory using standard methods. Eight different polymer types were identified from Station 1, 2, and 3 including, Polyethylene Terephthalate (PET), Polyethylene (PE), Polypropylene (PP) and Polyvincyl Chloride (PVC) materials known for their potential toxic effects. The polymer composition of microplastics was confirmed using the Fourier-Transform Infrared Spectroscopy (FTIR). The result showed that microplastics were abundant in station 3, (40.35%) and was relatively low in station 1 (26.07%). The mean and standard error (S.E) indicated low concentrations of microplastics in the upstream (13.00 ± 1.58) and high concentrations in the downstream (20.12 ± 1.70). The findings indicate that microplastics pollution in the Ikpoba River may have potential ecological and human health implications due to long-term exposure and bioaccumulation in the aquatic environment. Consequently, it is important for government agencies and environmental regulators to improve waste management practices, adopt stricter regulations for plastic disposal, and scale up public awareness campaigns to mitigate plastic pollution and protect aquatic ecosystems and human populations.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Plastics have significantly transformed modern society owing to their affordability, portability, sturdiness and ability to withstand biodegradation (Devriese *et al.,* 2015). These characteristics have actually enabled their excessive use across multiple sectors, which may include; packaging, textiles, household goods, and construction. Global plastic production has significantly increased to about 1.7 million tonnes in the 1950s to about 367 million tonnes in 2020, with projections suggesting it could reach nearly 590 million tonnes by 2050 (Hoang *et al.,* 2022). This is as a result of the high usage of plastics in ss, construction and household materials which provides lots of value to the people. The development of non-reusable plastics and a culture of disposability, specifically, have augmented the danger to the environment. (Onyena *et al*., 2024). The increasing production, use, disposal and degradation of plastic materials has led to the widespread environmental problem of microplastics. In recent years, they have received significant global attention due to the harmful effects they pose to ecosystems and living organisms. These tiny plastic particles can easily move through different parts of the environment and persist for long periods before eventually entering aquatic systems in various shapes, sizes and colours.

Microplastics come from several sources and are transported through multiple pathways, including stormwater runoff, wind action and improper disposal of plastic waste (Ogbomida et al., 2023). Their continuous accumulation in water bodies has raised concerns because of their potential impact on aquatic organisms, environmental quality and human health. In recent years they have been the subject of great concern throughout the world because of their devastating effects on ecosystems and living organisms.

Microplastics in the environment pose multiple ecological risks. They act as carriers of harmful substances, including toxic chemicals, contaminants, and potentially pathogenic microorganisms, thereby facilitating their dispersal across aquatic ecosystems. Aquatic organisms often ingest microplastics, leading to physical harm and the accumulation of toxic substances within their tissues. These contaminants can biomagnify through the food chain, becoming increasingly concentrated at higher trophic levels. Garrido-Gamarro *et al.* (2020) reported that compounds such as phthalates and polycyclic aromatic hydrocarbons (PAHs), which are often associated with microplastics, are capable of inducing serious health effects, including carcinogenicity, neurological disorders, and endocrine disruption. Their association with microplastic particles is particularly concerning because it facilitates their transport and persistence in environmental and biological systems. Consequently, identifying the types, abundance, and distribution of microplastics in aquatic environments is critical for accurate health risk assessment and for designing effective mitigation strategies (Bhuyan, 2022).

Furthermore, microplastics have been detected in a wide range of human exposure pathways, including table salt, drinking water, and even human fecal matter, indicating their widespread environmental presence. However, despite increasing evidence of exposure, there remains limited conclusive research on the direct impacts of microplastics on human health, highlighting an important knowledge gap. Recent studies have also reported the presence of microplastics in air, which raises additional concerns about inhalation exposure, particularly in densely populated regions.As a result, microplastic pollution threatens ecological integrity, biodiversity, and human health, particularly in communities that depend on aquatic resources for food security and livelihoods (Okorodo *et al*., 2024).

Ikpoba River is of considerable importance to residents of Benin City, as it serves multiple livelihood functions, including domestic water use, support for small-scale agriculture, and the maintenance of local aquatic ecosystems (Akpomie *et al*., 2014). Despite these benefits, recent evidence indicates increasing environmental stress within the river system, particularly due to the presence of diverse microplastic polymers, which signals growing ecological and public health concerns. Studies by Ogbomida *et al*., (2024) reported the dominance of polypropylene (PP), polyethylene terephthalate (PET), polystyrene (PS), and polyethylene (PE) in water samples collected from the Ikpoba River. These findings are consistent with earlier reports by Liu *et al*., (2021) and Okorodo *et al*., (2024), which also identified PE, PET, and PP as the most frequently occurring polymers in various aquatic environmentThe prevalence of these polymers in surface waters can be attributed to their relatively low density compared to water, which allows them to remain buoyant and accumulate at the surface. Their persistence in the upper water column increases the likelihood of ingestion by aquatic organisms across different trophic levels. Although the river continues to play a vital ecological and socio-economic role, the increasing presence of microplastics represents a significant threat to its environmental integrity and may pose potential risks to human health through continuous exposure and resource dependence.

. This study investigated the occurrence of microplastic pollution in surface water from Ikpoba River and help in understanding the concentration and varieties of polymers present in microplastics, establishing a foundation for future studies and policy measures intended to lessen the effects of contamination from microplastics in Benin City.

1.2 Justification of the Study

The persistence, bioaccumulation, and biomagnification of microplastics across different trophic levels have contributed significantly to their widespread occurrence in aquatic ecosystems. These particles can be retained within the bodies of living organisms, and their potential for accumulation generally increases as particle size decreases, making smaller microplastics particularly concerning (Frias *et al*., 2019; Tongo *et al*., 2022).In Benin City, Edo State, one of the major environmental challenges is the indiscriminate discharge of industrial effluents and domestic waste into nearby water bodies (Wangboje and Adeghor, 2024). This practice has led to the progressive contamination of aquatic ecosystems, posing serious risks to both aquatic biodiversity and human health (Idris *et al*., 2024). Given that water remains a vital resource for the residents of Benin City, it is essential to assess the extent of microplastic contamination in local water systems in order to protect public health and strengthen pollution management strategies

1.3 Aim and Objectives

This study aims to determine the levels of microplastics in the surface water of the Ikpoba River in Edo State, Nigeria. The objective of this study are:

1. To identify the concentration of microplastics at Ikpoba River sample locations upstream, midstream, and downstream.
2. To classify microplastics according to their morphology (films, fibres, or fragments) and identify the polymer compositions Polyethylene (PE), Polystyrene (PS), Polyethylene terephthalate (PET).
3. To determine which kinds of microplastic polymers are found in the river water samples.

CHAPTER TWO

LITERATURE REVIEW

2.1 Freshwater Resources

2.1.1 Global Distribution of River Resources

Rivers, lakes, reservoirs, wetlands, ponds, and groundwater systems are all examples of freshwater ecosystems. These environments make up less than one percent of the Earth's surface, but contain a variety of biodiversity. They are home to almost ten percent of all known species and more than 40% of all fish species (Dudgeon *et al.,* 2006). Rivers are one of the most dynamic systems on Earth. They are the major the hydrological pathway that carries about 20 billion cubic meters of water to the ocean every year. They also connect land, air, and sea environments in important ways (Vörösmarty *et al.,* 2010). There are more than 250,000 natural lakes around the world. About 17% of the world's total lake volume is found in Africa. Lake Victoria, which has a volume of about 2,424 km^3 and is well known as the second largest freshwater lake by the surface area (Lehner *et al.,* 2011). Ponds, on the other hand, are far more common; they are thought to number around 300 million globally. Even with their small size, ponds tend to have an unbalanced impact on regional biodiversity which could be very important for things like carbon sequestration and nutrient cycling. (Downing *et al.,* 2006). Also, artificial freshwater systems can be very useful in terms of conserving water in the world. Constructed impoundments, reservoirs hold an estimated 7,000 km^3 of water globally and provide vital tasks such as irrigation supply, flow control, and hydroelectric power generation (Lehner *et al.,* 2011). About 6–8% of the world's land area is made up of wetland ecosystems, which include swamps and floodplains. These ecosystems have an important role in providing key ecosystem services particularly through filtration of pollutants before entering into rivers (Davidson *et al.,* 2018). Surface water is used by humans on a large scale however Groundwater is the world's largest reserve of freshwater accounting for approximately 30 percent of all freshwater resources and supplying aquifers for nearly 2 billion people (UNESCO, 2022). In addition to their ecological and socio-economic roles, freshwater systems are becoming more vulnerable to pressures placed upon them by humans, including disposal of plastic waste which is now recognized globally as a serious issue.

2.1.2 Uses and Human Dependence on Freshwater

Most of the world's population depends on surface water supplies usually to fulfill their requirements for household, agriculture and industry. Approximately seventy percent of the world's surface water is used for irrigation; twenty percent is used for industrial purposes; and ten percent is used for residential purposes. According to UN-Water (2021), over half a billion people rely on surface water to obtain drinking water and perform other household tasks such as washing, cooking, and sanitation. In Nigeria, lack of adequate piped water services has caused the dependency on river water to increase severely. It is estimated that approximately 60 million people greater than one third of Nigeria’s population rely on either untreated or very minimally treated river water for their daily needs (NBS, 2023). An example of this is the Ikpoba River in Benin City where millions of people hope to obtain portable water for household use as well as to support local market activity and small-scale industry and provide drinking water for artisanal fishers (Ogbomida *et al.,* 2023). The increased human usage of surface water systems throughout the world particularly in developing countries can cause a new form of pollutants such as microplastics to be released into the environment posing potential ecological and public health risks. A lot of rural areas usually rely on seasonal reservoirs or ponds as their main source of water for watering, fishing, and drinking. Urban populations tend to draw water from boreholes or shallow aquifers. Groundwater provides nearly half of all household water in Sub Saharan Africa, with the exception, being arid regions where there are very few surface water resources (MacDonald *et al.,* 2021). Rivers are culturally and spiritually significant; the practice of bathes, ritual cleansings, and celebrations remains a part of the history of many riverine locations in West Africa which involves; Niger River, Benue River and Ogun River, indicating continued social and cultural practices (Oestigaard, 2017). As such, approximately 1.8 billion people around the world currently use unclean surface water sources, thereby increasing the number of individuals exposed to water borne illnesses (WHO and UNICEF, 2023). Therefore, the broad dependence upon fresh water systems will exacerbate the impact of future contaminants entering these systems including plastic debris and microplastics.

2.2 Microplastics and their sources

2.2.1 Primary Sources

Primary microplastics are produced and manufactured for particular applications at the company and industry level. They are generally produced as micro pellets, fragments or as micro-spheres (microbeads) for use in a wide variety of consumer products, including cosmetic and personal care products as well as in industrial cleaning products (Idris *et al.,* 2024). They are also used as abrasives, for example, in the process of shot blasting. The fact that these primary microplastics are already produced in very small sizes means that they can easily be released into the environment directly through wastewater discharges or through handling of these products during their manufacture, transport and use (Olarinmoye *et al.,* 2020). Synthetic textile fibres such as Dacron, kevlar and synthetic wool also produce microfibres during their production, washing and wear which are then released into the wastewater system and the environment

(Ganesan *et al.,* 2019). Microfibres have also been detected in a wide range of environmental matrices including drinking water, food products, aquatic organisms, air, soil and all water types (Fred-Ahmadu *et al.,* 2024). This increasing level of microplastic contamination of the environment indicates a growing threat to the environment and ecosystems.

2.2.2 Secondary Sources

When larger plastic materials break down into tiny particles smaller than five millimeters due to ecological degradation processes, secondary microplastics are created. These processes, which gradually weaken plastic polymers in natural environments, include photodegradation from ultraviolet polarization, mechanical deterioration, thermooxidation, and microbiological movement (Andrady, 2017). Over 79 million metric tons of microplastics are released into the environment each year, most of which come from improperly managed residues. A considerable amount of this waste eventually finds its way into aquatic systems, where ongoing degradation produces numerous amounts of secondary microplastics (Jambeck *et al.,* 2015). In many African countries, sanitation services that are not up to standard such as open dumping and uncontrolled flaring accelerate plastic deterioration and increase the release of microplastic particles into river systems (UNEP, 2021). Agricultural plastic inputs represent an important pathway for secondary microplastic formation. Under environmental stressors, polyethylene, polypropylene and mulch films gradually break apart, producing microsized particles that are released into nearby soils and aquatic systems by irrigation techniques and stormwater runoff (Huang *et al.,* 2020). Furthermore, fishing gear, drink containers, and packaging materials are examples of microplastic debris that is subjected to extended environmental weathering. Polyethylene and polypropylene are thought to last between 100 and 400 years in natural settings, though their rates of degradation vary depending on the polymer composition and UV exposure (Chamas *et al.,* 2020).

2.3 Distribution of Microplastics in Aquatic Systems

2.3.1 Entry Pathways from Land to Water

According to Dris *et al.,* (2016), microplastics can enter freshwater systems in two ways: direct discharge and diffuse transport. Pollutant discharge points refer to water recycling facilities. Although these facilities can achieve retention efficiencies between 88 and 99 percent, they rarely remove all pollutants. Murphy *et al.,* (2016) discussed how treated effluent continues to release significant amounts of microplastic particles into water habitats, estimated at between 10^{1} and 10^{o} particles per day. Once released into the environment, microplastics spread through various channels. Stormwater drainage systems, agricultural runoff, and sewer overflows all help move them into rivers and lakes.

Furthermore, lighter plastics can also be carried by wind from the surface of land into nearby water bodies. Nwonumara *et al.* (2021) reported that such connections lead to the gradual transfer of microplastics from freshwater to downstream water bodies. Microplastics also make their way into aquatic food chains and pose a threat to human consumption of the affected food sources. This becomes evident considering the growing body of evidence regarding toxicity and potential harm to ecosystems posed by these substances due to increased exposure to them (Danopoulos *et al.,* 2020). The problem is aggravated by combined sewer overflows (CSOs), which directly discharge contaminated sewage containing microplastics into streams and rivers due to heavy rainfall (Gaspari *et al.,* 2021).

Furthermore, the manufacture of plastics, together with the inadequate management of landfills, causes localized hotspot pollution, whereby leaching and direct discharge cause an increase in the density of particles in surrounding water bodies (Luo *et al.,* 2019). The most important factors in the decomposition of microplastics in urban freshwaters include the sites that facilitate diffusion. As much as seventy to eighty percent of microplastics present in urban rivers originate from stormwater runoff, which includes tire debris, textile fibres, and remaining road markings (Siegfried *et al.,* 2017). Microplastic particles tend to reach water bodies through atmospheric deposition, at levels between 0.01 and 1 particles per cubic metre, while fibre particles may settle at distances up to 100 kilometres from their origin (Dris *et al.,* 2016). Agricultural runoff also plays a significant role in freshwater pollution by carrying fragments from deteriorated mulch films and fertilizer plastics (Piehl *et al.,* 2018).

2.3.2 Transport from Rivers to Oceans

The main microplastics route from the earth's surface to estuarine habitats is through rivers. According to Lebreton *et al.* (2017), river systems bring one to two million metric tonnes of plastic waste into the oceans each year. The Yangtze, Nile, and Niger are the rivers most affected by pollution. The density of polymers affects how microplastics behave in water. Low-density polymers, like polyalkenes, float on the water's surface. After two to six weeks, they settle and interact with benthic habitats due to biofouling by algae and bacteria (Fazey and Ryan, 2016). During rainy seasons, microplastics attached to sediments may be disturbed during floods, resulting in increased transport downstream (Hurley *et al.,* 2018).

According to Zhang *et al.* (2019), reservoirs often act as temporary storage, holding 60 to 80% of incoming microplastic particles for several months to years. This process reduces their release later on. Microplastics also get trapped in estuarine environments due to turbulent mixing and interactions with suspended sediments. This delays their entry into marine systems and impacts their spatial distribution from rivers to oceans (Vermeiren *et al.,* 2021). When these processes occur, they demonstrate how hydrodynamic forces, sediment interactions, and retention in reservoirs and estuaries influence the movement of microplastics from rivers to marine environments. These factors could also affect when and how many particles are found and where they are located.

2.4 Effects of Microplastics

2.4.1 Environmental Persistence and Degradation

Plastics have a chemical stability that leads to ongoing environmental issues since they do not decompose easily. Depending on the kind of plastic and the environmental conditions at the time of disposal, it may take hundreds of years to thousands of years for plastics to fully decompose (Oladunjoye *et al.,* 2025). Exposure to UV light, water, wind, and physical forces (like friction and abrasion) break down the larger plastics into small fragments referred to as microplastics. Once created, microplastics become trapped in an ecosystem and continue to increase in size and number until they reach their maximum accumulation; in some cases, this can take anywhere from 100 to 1,000 years. In many cases, the most significant concern is how long plastics last once they enter an ecosystem. For example, polyethylene (PE) may take up to 100-600 years to degrade when exposed to UV light; other plastics, like thermoplastics, can remain in the environment for longer than 1,000 years (Andrady, 2011). When plastics break down into nanoscale pieces (smaller than one micrometre) they increase the amount of surface area available to interact with their environment. This provides more opportunities for interaction with living organisms.

2.5 Effects of Microplastics on Freshwater Systems

2.5.1 Physical and Hydrological Impacts

Microplastic contaminants alter the physical make up of freshwater environments through modification of sediment parameters and parameters in the water column. The presence of microplastics has been experimentally shown to decrease the porosity of sediments by approximately 10 to 20 percent. Therefore, the ability of sediments to facilitate oxygen diffusion into the benthic environment is compromised and benthic habitats are compromised as a result (Redondo Hasselerharm *et al.,* 2018). In addition, elevated levels of microplastics in the water column have been found to increase water turbidity and reduce light penetration. As such, the photosynthetic capabilities of submerged macrophytes are reduced due to limited light availability (Kalčíková *et al.,* 2017). Furthermore, the accumulation of microplastic particles in hyporheic zones may disrupt normal flow dynamics in streams and rivers as they interfere with the exchange processes at the literal zone where surface and groundwater interact (Wagner *et al.,* 2018).

2.5.2 Chemical Contamination and Nutrient Cycling

The hydrophobic surfaces of microplastics enable the adsorption of carbon-based compounds, such as heavy metals, polyaromatic hydrocarbons, and organochlorines. Rochman *et al.,* (2013) stated that the Freundlich isotherm model's description of sorption behaviour, involves the combination of pollutants on plastic particles which may level up to one million times higher than those found in nearby waters. This model relates with microplastics because it measures how they are used as mobile vectors that spread harmful substances throughout aquatic environments majorly because of their strong affinity for pollutants. Also, through binding phosphate and nitrate ions, microplastics can disrupt nutrient dynamics as well as aiding the movement of contaminant, which potentially decreases microbial nitrification efficiency by 20 to 30 percent (Seeley *et al.,* 2020).

2.6 Effect of Microplastics on Freshwater Organisms

Invertebrate and vertebrate organisms that unintentionally take in particles from the water column and sediments are at significant risk from the presence of microplastics in freshwater food webs. Also there are physical interactions that can occur after exposure which contributes to the decline in biodiversity. They include; Entanglement, gastrointestinal obstruction, and internal tissue damage (Akindele *et al.,* 2019). After ingestion, microplastics can remain in the tissues of organisms, enabling bioaccumulation and trophic transmission to higher trophic levels. (Jia *et al.,* 2022).

2.6.1 Ingestion and Physical Damage

Microplastics have been found to be eaten by a lot of different types of freshwater animals. This is mostly because the particles are about the same size as natural food sources. If you eat these particles, they can block your intestines, cause cuts inside your body, and make it harder for your body to absorb nutrients. This can make feeding and using energy less effective. Studies have shown that fish can eat between 1 and 10 microplastic particles per person, which can block their intestines, make them feel full, and slow their growth by 10 to 30 percent (Jovanović, 2017). Zooplankton that were exposed to high concentrations of 10^5 particles per cubic meter have shown up to 50% feeding inhibition and about 20% death within 96 hours (Zocchi and Sommaruga, 2019). In the same way, bivalves are known to have taken in 100 to 1,000 particles per gram of tissue, which makes it harder for them to filter and affects their health (Sussarellu *et al.,* 2016).

2.6.2 Chemical Toxicity and Physiological Stress

When microplastics are being consumed, they can release endocrine disruptors that are already in them into nearby tissues. Studies have shown that fish exposed to these chemicals at levels between 0.1 and 1 mg/L experience oxidative stress. The median lethal dose for phthalates in zebrafish are known to be around 0.5 mg/L (Barboza *et al.,* 2018). The transfer of chemicals through trophic transfer increases its harmfulness. Moreover, polymer nanoparticles themselves do not accumulate well in the organism; however, additives such as polybrominated diphenyl ethers were observed to accumulate in predator fish by an order of magnitude more (Miller *et al.,* 2020).

2.7 Effects of Microplastics on Humans Consuming Freshwater

2.7.1 Exposure Pathways

People mostly come into contact with microplastics by eating and drinking food and water that has been polluted by the sea. Research shows that tap water can have as many as ten microplastic particles per liter, and bottled water can have as many as 10,000 particles per liter. Most of these particles are made of polyethylene terephthalate (PET) and polypropylene (PP), and they usually come from bottle caps and packaging (Mason *et al.,* 2018). Also its being said that people in places like Nigeria that use untreated river water may drink about two liters of it every day, which could mean they take in about 7,300 microplastic particles a year (Oßmann *et al.,* 2018). Freshwater fish have been found to have between 0.1 and 10 microplastic particles per serving, and people who eat fish twice a week could eat up to 11,000 particles a year (Cox *et al.,* 2019).

2.7.2 Health Implications

Microplastics have been identified in several human tissues, including feces, blood, placental tissue, and lungs, where their presence has been linked to inflammation, oxidative stress, and disturbances in immunological function. (Leslie *et al.,* 2022). Phthalates and other chemical additives can leach from these particles and have been linked to endocrine damage in blood serum at levels between 0.1 and 10µg/L (Katsikantami *et al.,* 2020). Regular exposure to microplastics and their associated pollutants may exacerbate inflammatory responses, potentially elevating long-term cancer risk (Wright and Kelly, 2017).

2.8 Global Perspective on Microplastic Pollution

Plastics have been produced in large quantities since the early 1900s. So, as at now they are an important part of both industrial and consumer systems. They are used in a lot of different things, like textiles, packaging materials, medical supplies, and household goods (Cera *et al.,* 2020). But poor waste management and throwing things the wrong way have caused plastic trash to get into both land and water environments. Plastic pollution is a big problem for the environment all over the world, but it has grown much of a bit of concern in water ecosystems. Plastics are known to last for a long time and they actually spread so fast because they are strong and holds no weight. The global production of plastic has increased significantly over the last 70 years. In 2018, it increased to approximately 360 million metric tonnes from roughly 1.5 million metric tonnes in 1950 (Galgani *et al.,* 2010). An estimated 4.8 to 12.7 million metric tonnes of this volume enter the oceans annually through various river and land based routes (Horton *et al.,* 2017). It is predicted that, if present consumption trends continue, the yearly production of plastic could reach 2 billion metric tonnes by 2050. Also with the rate at which these plastics are increasing, it may cause environmental stress for the terrestrial, freshwater and marine systems, and this is why attention is needed to stop these pollutants from spreading.

Microplastics were first reported in the 1970s, but in the last few years they have become one of the most common types of plastic pollution around the world. These particles, which are plastic pieces less than 5mm in diameter, are usually made of synthetic polymers with different chemical additives. There are two main types of microplastics: primary microplastics, which are made on purpose to be very small (like microbeads in personal care products), and secondary microplastics, which are made when larger plastic debris breaks down and breaks apart (Pradhan, Patel, and Krishnan, 2022).

Microplastics are readily digested by lower trophic organisms, such as plankton, and subsequently ascend the food chain to higher trophic levels, such as fish. As a result, microplastics have an easier time passing through aquatic food webs. (Andrady, 2011; Smith *et al.,* 2018). The breakdown of improperly managed plastic waste, tyre wear particles, synthetic textile fibres, and cosmetic formulations are some of the main sources. Microplastics have been found in freshwater, marine, and terrestrial environments, including remote areas like Mount Everest, where atmospheric transport, surface runoff, and human activity contribute to their distribution due to their persistence, small size, and excessive mobility (Lamichhane *et al.,* 2023). The most frequently found polymers in environmental microplastics are polyethylene (PE), polypropylene (PP), and polystyrene (PS), which are often seen as fibres and irregular fragments. (Ghosh *et al.,* 2023). Microplastics tend to affect biological systems chemically and physically by changing the structure of the soil, influencing physicochemical characteristics, and decreasing biodiversity, these particles interfere with the functioning of ecosystems. They may carry hazardous substances, such as metals and hazardous pollutants, throughout the environment and leach intrinsic additives and monomers. These adsorbed materials have the capacity to build up and proliferate throughout trophic levels, which would cause a threat to everything from zooplankton to higher mammals (Lamichhane *et al.,* 2023). Humans are mostly exposed to microplastics by breathing in airborne particles and eating or drinking contaminated food or water. Human blood, stool, placental tissue, and other organs have been found to contain microplastic particles in recent studies, raising grave concerns for public health. (Li *et al.,* 2023; Vethaak and Legler, 2024). Emerging evidence indicates that microplastics may cause imbalance, inflammatory responses, and cellular toxicity. Despite the fact the sustained health implications remain under investigation, potential risks include respiratory disorders, immune dysfunction, and other chronic conditions associated with prolonged exposure. Regional patterns of microplastic in lakes are not apparent in the whole world as microplastic concentrations vary in response to the point sources of pollution and also due to the uneven sampling studies throughout the world. As an example, the information about the microplastic pollution of Lake Baikal, the largest freshwater lake in the world, which is situated in Russia, is not available (Hale *et al.,* 2020). Nevertheless, Eriksen *et al.* (2013) found that the mean concentration of microplastics in Lakes Superior, Huron, and Erie was approximately 43,000 particles per square kilometre (0.27 particles per cubic metre). Conversely, Baldwin *et al.,* (2016) found more concentrations closer to large cities, of the order of 466,000 particles per square kilometre (equivalent to 2.9 particles per cubic metre). Eriksen *et al.* (2013) also established that Lake Erie which has higher population of urban areas in its watershed compared to Lake Superior and Lake Huron portrayed higher levels of microplastic pollution.

Some European lakes have been discovered to contain microplastics. In Italy, the lake Chiusi had 2.68-3.36 particles per cubic metre, and the lake Bolsana had 0.82-4.42 particles per cubic metre (Fischer *et al.,* 2016). Lake Taihu in China exhibited a variation according to the location, with the lowest point of 0.3 in the centre, and the highest point was 1.1 and 2.5 in the northwest, and southeast, respectively (Su *et al.,* 2016). As high as 4,137 particles per cubic metre, microplastic was detected on the surface waters of the Yangtze Estuary (Zhao *et al.,* 2014). Microplastics were discovered in rivers and lakes on the Tibetan Plateau, mostly in the southwest, south and northeast, but little is known about the north-western region (Wang *et al.,* 2023). Renuka Lake had the highest average with 21 ± 13 items per liter in India. Polypropylene, polyethylene, polyethylene terephthalate and polyester were the most prevalent types of plastics that were found. The microplastic debris has been detected even in remote and isolated areas, like the Ross Sea near Antarctica (Grover-Johnson, 2018). Fishing, tourism, research and supplying of Antarctic stations are some of the activities that are mostly contributing to pollution in the Southern Ocean. In 10 metres deep, Grover-Johnson (2018) found an average of 0.001 to 0.15 per cubic metre of microplastics.

Akindele *et al.* (2020) established the existence of microplastics in freshwater systems throughout the continent of Africa. Their research compared the two methods, mFTIR spectroscopy and visual analysis and they concluded that mFTIR gave more confidence when identifying microplastic polymers since the visual analysis method gave inconsistency in results most of the time. Fibrous microplastic was prevalent in the rivers of Africa. In recent times, a few African nation, such as Kenya, Uganda and Tunisia have implemented the use of paper bags instead of polyethylene based bags as other European countries have done. Nigeria, with the fastest population growth rate, which is expected to make it the third most populous country in the world by 2050 (UN DESA, 2017), is in dire need of similar policies and more intensive campaigns against the use of plastic pollution.

The widespread distribution and environmental persistence of microplastics pose escalating risks to aquatic ecosystems and public health. In response, several developed regions have implemented regulatory interventions aimed at reducing plastic leakage at source. The European Union has passed more comprehensive regulations aimed at disposable plastics and banned the use of microbeads in personal hygiene products. In a similar vein, the US and Canada have proscribed microbeads from cosmetic formulations in an effort to reduce primary microplastic emissions. (UNEP, 2021). However, progress towards the solution of this issue on a global scale has yet to be reached. Plastic usage experienced an all-time peak during the outbreak of the corona virus pandemic owing to single-use packaging and personal protective equipment that caused more plastic wastes to be generated and dumped into the environment (Strokal *et al.,* 2023). Most developing countries, particularly African states, still experience the problem of plastic pollution due to poor policy implementation, lack of waste management systems, and recycling capabilities; conversely, strict legislation aimed at boosting development has been implemented in developed countries. The existence of these disparities underscores the necessity for sustainable production-to-consumption practices, improved waste management systems, and global governance mechanisms.

Summary of the Review:

Currently, plastics are regarded as very important. But the fact is that plastics have turned out to be one of the biggest environmental issues because of their robustness and lack of proper waste management. There is a constant influx of microplastics into the aquatic ecosystem because of the exponential increase in the production of plastic material. The term 'microplastic' refers to the plastic pieces less than five millimetres in diameter. These microplastics are formed because of synthetic materials used in making clothing items, cosmetics, tires, and other plastic products.

High concentration levels of microplastics are always found close to highly urbanized and populated areas, based on a review done concerning freshwater bodies globally. The main forms of these plastics are fibrous and fragmentary, with most of them being composed of polyethylene, polypropylene, and polystyrene. Microplastics pose great harm to nature through destruction of eco-systems and introduction of toxic substances in the food chain. Humans come into contact with these harmful particles through drinking water, consumption of seafood, and even breathing polluted air. As a result, health problems including chronic illnesses may arise among individuals due to inflammation caused by these pollutants. Despite the fact that many advanced countries have formulated regulations concerning plastics management, poor management in developing countries is still a challenge due to lack of strict policies and proper enforcement.

2.9 Microplastics in African and Nigerian River

Studies on microplastics in African aquatic systems is still emerging but has already shown pollution levels that exceed some global averages. Fibres and fragments continue to be the most prevalent forms found in aquatic systems, sediments, and aquatic biota (Nyaga *et al.,* 2024). In South Africa, studies have recorded alarmingly high prevalence rates, including a 100% occurrence in the Vaal River, where sediment concentrations reach up to 1.1×10^3 particles/kg, with higher levels typically observed during the wet season (Ramaremisa, Ndlovu and Saad, 2022; Yakubu *et al.,* 2024). Other river systems such as the Nyl, Mogalakwena, and Limpopo Rivers exhibit marked seasonal variations, with greater microplastic accumulation occurring during low-flow periods, particularly near wastewater discharge zones (Mthembu *et al.,* 2025). An average of 21.6 microplastic particles per cubic metre were found in surface waters next to the Kenyan coast. The most prevalent polymer was condensed polyethylene, which makes up 38.3% (8.29 ± 3.27), followed by low-density polyethylene at 27.1% (5.87 ± 2.6), and polypropylene at 34.6% (7.48 ± 4.84) particles per cubic metre (Kerubo *et al.,* 2021).

Across Sub-Saharan Africa, ineffective waste management systems and limited recycling practices have greatly contributed to the accumulation of microplastics. In Nigeria, plastic pollution remains persistent and appears to intensify, regardless of regulations put in place to address the issue of laws that are either poorly implemented or weakly enforced (Wirnkor *et al.,* 2019). Enyoh *et al.,* (2019) reported that plastics accounted for 59% of the 3,487 macrodebris items per square meter collected along the shores of rivers in Nwangele Local Government Area, Imo State. Likewise, a study conducted on the Cross River, Qua Iboe River, and Jaja Creek in Akwa Ibom State recorded a high concentration of plastic litter (>5,000 kg/m^2), far exceeding other waste types such as foil (<1,000 kg/m^2) (Babatunde and Arinze, 2018). Imhof *et al.,* (2013) similarly observed a high abundance of polyethylene (PE) and polystyrene (PS) microplastics in the lakeshore sediments of Lake Garda, Italy a finding that is unsurprising given that PE and PS are among the most widely used plastic materials that frequently escape into the environment. Enyoh *et al.,* (2019) identified small-sized microplastics, measuring around 11 µm, in the surface waters of Obiaraedu, Nwangele, Okumpi, Ogbajarajara, and Onuezuze Rivers, with concentrations ranging from 440 to 1,556 particles per liter. The shapes that were very obvious in the analysis were fibres, fragments, and films and they are made up of polyethylene and polyethylene terephthalate. This findings literally confirms that the major cause of microplastic contamination is due to human activities. It was also reported that the concentration of microplastic in Nigerian surface waters could eventually reach as high as 22,079 particles per liter, while sediments found in Ethopian lakes had up to 124,000 particles per cubic meter. Akindele *et al.,* (2019) also did his research and observed that polyethylene fibres have accumulated in gastropods from the Osun River. It was practically the first report ever in West Africa.

Most research has been focused on environmental contamination by microplastics globally. It has also been done on various continents including Europe, Asia and the Americas, microplastic contamination in Nigeria is poorly understood. The preliminary works that have been done indicate that there is microplastic presence in Nigeria's freshwater systems. This likely will only worsen as plastic production and consumption continues rising. Consequently, it is imperative to conduct a comprehensive study which would quantify and characterize microplastics pollution in air (atmosphere), soil and water in different environments in Nigeria. Such study will assist in ascertaining the extent and fate of microplastic in Nigeria. The urban waste and the fibre fabrics and packaging materials mainly of polyethylene and polypropylene are the major sources of pollutants that can cause threat to biosphere and people's wellbeing due to bioaccumulation and nutrient flow (Enyoh *et al.,* 2019).

Summary of Literature Review

The amount of microplastic pollution in African waters is increasing and frequently exceeds the global average. Most fibres and fragments have been found in rivers in Kenya and South Africa, especially close to wastewater outlets. Inadequate recycling and waste management practices throughout Sub-Saharan Africa have made the issue worse. Although plastic pollution problem still exists in Nigeria, surface waters are have been proven to be high in microplastics, with over 20,000 particles per liter, due to various results from different analysis. More importantly, It was revealed that the majority of microplastics are tiny polythene and polystyrene fibres and fragments which indicated that the contamination of these rivers have grown at a very high rate, most likely due to the result of inappropriate disposal and uncontrolled urban runoff. We believe that the data on microplastic pollution in Nigeria is still insufficient. More extensive studies of the earth's air, soils, and waters are required to fully understand its scope, routes, and ecological risks.

CHAPTER THREE

MATERIALS

3.1 Study Area

Ikpoba River was the site of the study, a fourth-order stream situated in Benin City, Edo State, Nigeria. The city is located between latitudes 6°11' and 6°29'N and longitudes 5°33' and 5°47'E (Obayagbona and Odigie, 2025). Ikpoba River originates from the northern Ishan Plateau, it flows southwest through a steep sandy valley before entering the urban expanse, where it is impounded by the Ikpoba dam (constructed in 1977) to form the Ikpoba reservoir a critical source of portable water for over 1.5 million residents (Idemudia *et al.,* 2023). The river lies between Latitude 6021’30’’N and 6023’05’’N and Longitude 5038’16’’E to 5039’38’’E. Within the city, the estimated length of the river is about 13.57 km^2 with the dam at the center (Obayagbona and Odigie, 2025). Three sampling sites were selected along the river: Site 1 (Ikpoba Slope), Site 2 (Temboga), and Site 3 (Guinness Brewery) (Figure 3.1). These locations were chosen due to the visible presence of plastic waste and their proximity to areas receiving industrial effluent discharges.The river receives inputs from domestic effluents, market runoff, and small-scale industrial activities such as sawmills, rubber processing facilities, and mechanic workshops (Wangboje *et al.,* 2013; Ogbomida *et al.,* 2023). The high level of plastic pollution in the river makes it an ideal location for studying microplastic contamination.

3.2 Sample Collection

Samples were collected from July to August, 2025. A total of thirty (N=30) water samples were taken from Ikpoba River using pre-cleaned glass bottles of size 0.75L. At each location, three replicate samples were taken at random from a meter below the water surface, which was filtered using a 0.48µm stainless sieve and aluminum bucket.

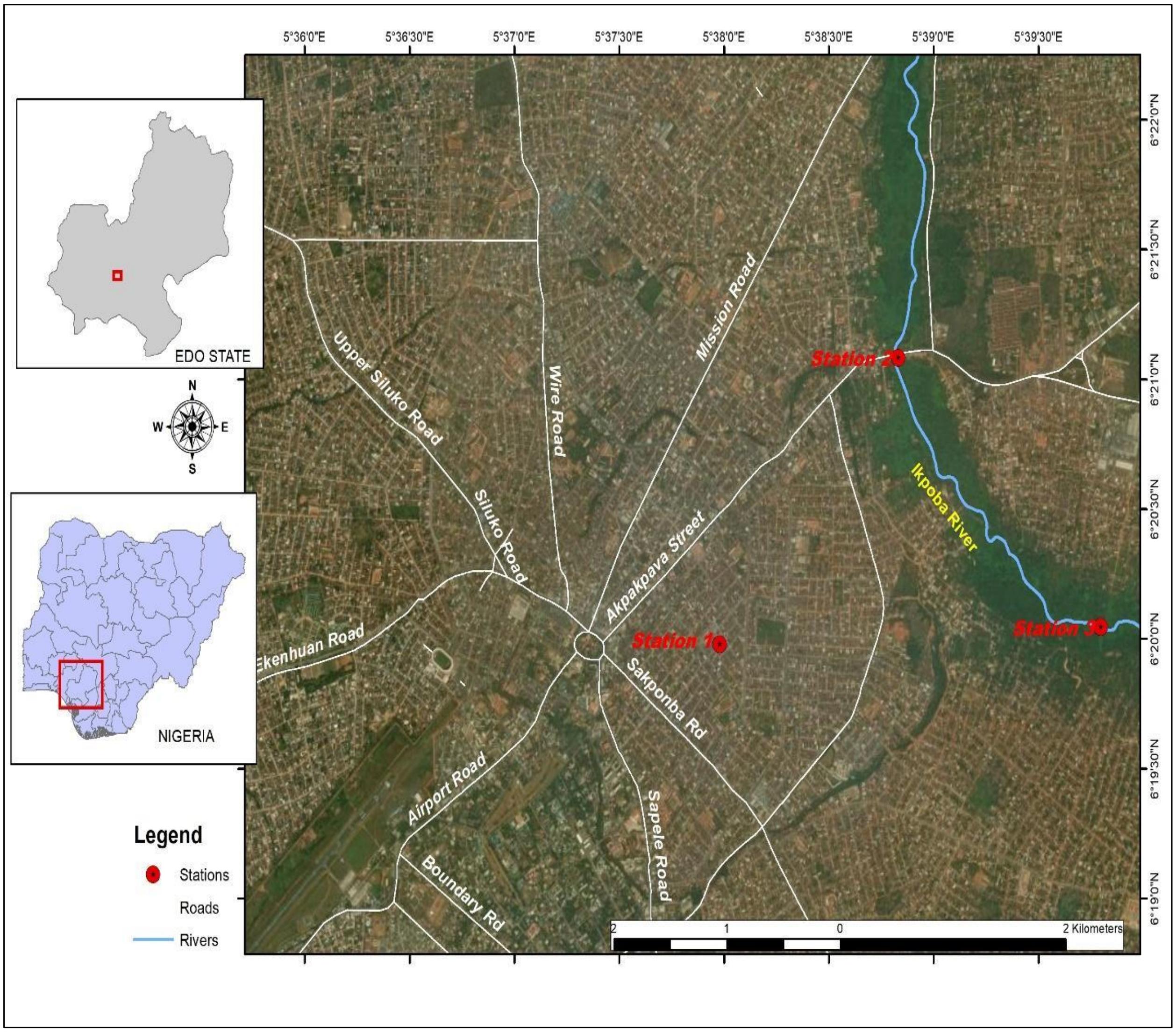

Figure 3.1: Map of the Study Area

These samples were stored in a cold storage with cooling temperature at four degrees Celsius and moved in a cooler with ice to a laboratory for analysis at the Department of Biological sciences, Redeemer's University, Osun State, Nigeria.

3.3 Removal of Microplastics from Water

Glass bottles were used to collect surface water samples, which were subsequently transported to the laboratory. The water samples were shaken to mix the samples. To avoid clogging, the 50 mL of the water sample was treated with 30 mL of 30 % Hydrogen Peroxide for 20 mins. The sample was then passed through a Whatman GF C filter paper with a pore size of 1.2 mm and a diameter of 47 mm. This was done with the aid of a vacuum pump, a filtration flask and a glass funnel. The filter papers were dried overnight in the fume hood. This method was done in accordance with the method described by Therese *et al.* (2017).

3.4 Fourier-Transform Infrared Spectroscopy (FTIR) Analysis

Microplastics extracted from samples in water were analyzed using Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FTIR) spectroscopy on a Perkin Elmer FTIR Spectrum 2 spectrometer. Samples were chosen both randomly and by selecting the most frequent microplastic types found in each sample location. FTIR helped to showcase the types of polymers in the microplastics taken from the samples. It also made it possible to see the distinct features of each microplastic particle, which allowed for accurate identification of their polymer types. The dried filter samples were sent over for FTIR analysis in glass petri dishes and wrapped with foil fume hood. This method was done as to what was obtained by Therese *et al.,* (2017), papers to avoid contamination. About 200 mg of potassium bromide powder and 1 to 3 mg of finely crushed microplastic sample were mixed together, then pressed for one minute at a steady pressure of 10 tons in a pellet press. This produced a clear pellet. The system was kept under evacuation during the FTIR procedure, and the pellet was fully examined with an FTIR spectrophotometer set at a level of two centimeter for a total of thirty scans. Polymers were identified using FTIR spectroscopy, aided by the internal library of the FTIR spectrophotometer. The identification was confirmed by matching the FTIR spectra obtained with the literature data (Manalo *et al.,* 2023).

3.5 Statistical Analysis

The microplastic data collected from the Ikpoba River were subjected to descriptive analysis and one-way ANOVA in order to provide summary measures and identify statistically significant differences in abundance across all sampling stations. All analyses were carried out using the software program IBM SPSS Statistics (Version 26), and the confidence level of 95 percent was employed in all analyses ($p < 0.05$).

CHAPTER FOUR

RESULTS

4.1 Percentage Abundance of Microplastics in Water Samples from Ikpoba River

Table 4.1 depicts the various polymers of microplastics in the surface waters of the Ikpoba River. It was observed from the data that there was a significant difference in the relative abundance of microplastic polymer types among the three sampling locations. Relative abundance of 26.07% and 33.58% was noted in stations 1 and 2, respectively. Meanwhile, the highest percentage was noted in station 3, where 40.35% of the microplastic polymers were identified, as depicted in Figure 4.1.

Table 4.1: Percentage Abundance and Mean of Microplastics in Water Samples

Mcroplastics	Station 1 (%)	Station 2 (%)	Station 3 (%)
Polyethylene terephthalate	20.19	17.16	18.63
Polyethylene	10.58	14.18	13.66
Polyamide	11.54	16.42	12.42
Polyurethane	9.62	9.70	11.18
Polypropylene	16.35	14.18	12.42
Polystyrene	14.42	11.19	9.94
Polycarbonate	7.69	7.46	8.70
Polyvincyl chloride	9.62	9.70	13.04

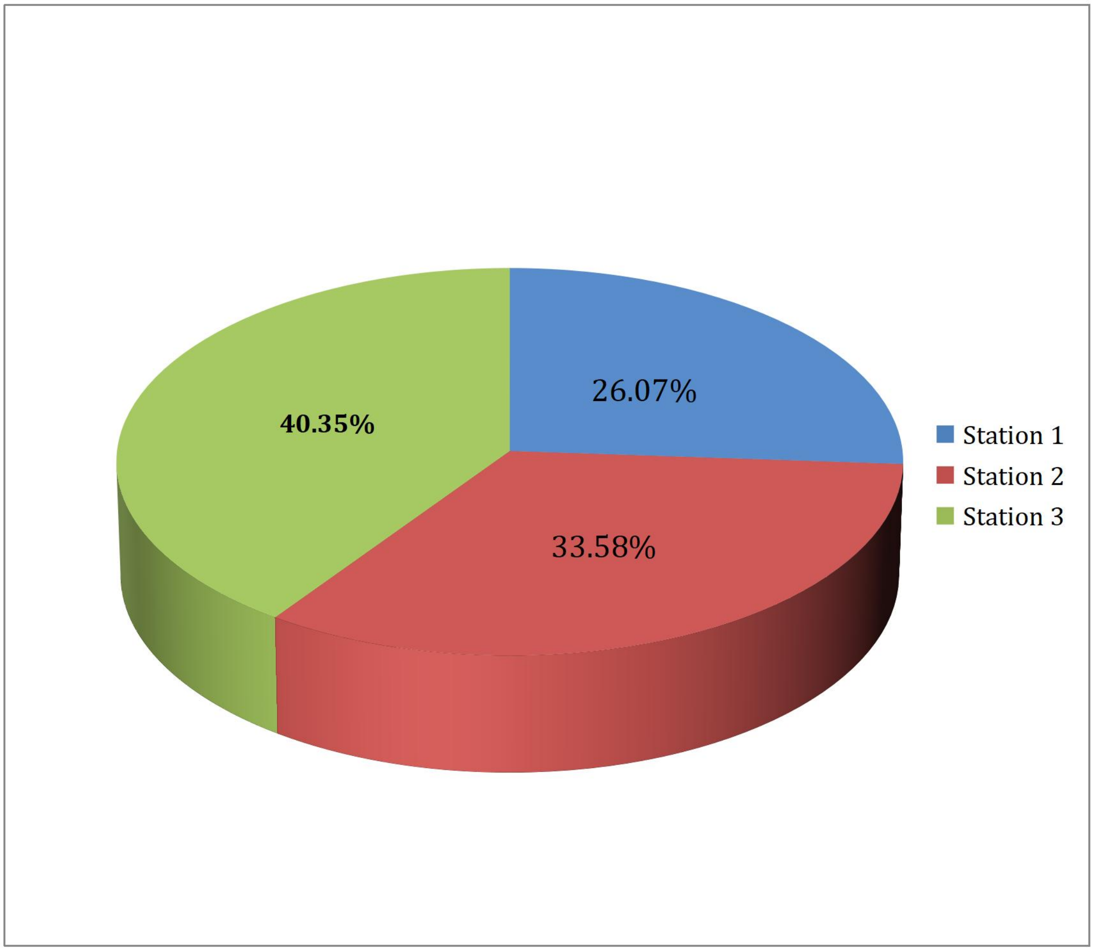

Figure 4.1: Percentage Abundance of Microplastics Distributed across the Stations in Water.

Table 4.2: Mean ± Standard Error of Polymers in various Stations

Stations	Mean	±	Standard Error
Station 1	**13.00**	±	**1.58**
Station 2	**16.75**	±	**1.49**
Station 3	**20.12**	±	**1.70**

The average percentages of the polymer microplastics obtained at the sampling stations are shown in Table 4.3. The average percentage of polyethylene terephthalate was the highest at 18.66%, followed by polypropylene at 14.32% and polyamide at 13.46%. Polyethylene had an average percentage of 12.81%, while polystyrene and polyvinyl chloride had average percentages of 11.85% and 10.79%, respectively. Polyurethane had an average percentage of 10.17% recorded the least abundance at 7.95%

Table 4.3: Mean Concentration Percentage for each Microplastic across Stations

Microplastics	Mean Percentage (%)
Polyethylene terephthalate	18.66
Polyethylene	12.81
Polyamide	13.46
Polyurethane	10.17
Polypropylene	14.32
Polystyrene	11.85
Polycarbonate	7.95
Polyvincyl Chloride	10.79

Distribution of small plastic fragments among the three sampling sites is shown in Table 4.4 There were 104 small plastic fragments, constituting 26.07% of the total number, identified in station 1. There were 134 pieces, which constitutes 33.58% of the total small plastic fragments at station 2. Station 3 had the most plastic fragments, a total of 161 pieces, which made up 40.35% of the total number of small plastic fragments.

Table 4:4: Percentage Abundance of Microplastics Distributed across the Stations in **Water**

Stations	Total Count	Percentage (%)
Station 1	104	26.07
Station 2	134	33.58
Station 3	161	40.35

Table 4.5 shows the variation in the abundance and composition of microplastic types across the sampling stations. Polyethylene terephthalate (PET) recorded the highest mean abundance (24.67 ± 2.73), with values ranging from 21 to 30 particles. Polypropylene revealed relatively high occurrence with a mean value of 18.67 ± 0.88 and a narrow range of 17–20. Polyamide and polyethylene had comparable mean abundances of 18.00 ± 3.06 and 17.33 ± 3.38, respectively, although both exhibited wider ranges (12-22;17-20).

Table 4.5: Variation in the Abundance and Composition of Microplastic Type across Stations

Microplastics	Mean	Std. Deviation	Std. Error	Min	Max
Polyethylene terephthalate	24.67	4.73	2.73	21	30
Polyethylene	17.33	5.86	3.38	11	22
Polyamide	18.00	5.29	3.06	12	22
Polyurethane	13.67	4.04	2.33	10	18
Polypropylene	18.67	1.53	0.88	17	20
Polystyrene	15.33	0.58	0.33	15	16
Polycarbonate	10.67	3.06	1.77	8	14
Polyvincyl Chloride	14.67	5.86	3.38	10	21

Polystyrene recorded a mean abundance of 15.33 ± 0.33 with the least variation (15–16). Polyvinyl chloride (PVC) and polyurethane had moderate mean abundances of 14.67 ± 3.38 and 13.67 ± 2.33, respectively. In contrast, polycarbonate recorded the lowest mean abundance (10.67 ± 1.77), with values ranging from 8 to 14 particles.

4.2 FTIR Analysis of Microplastics in Water Samples from Ikpoba River

The FTIR features of microplastics extracted from the water samples obtained from the three sampling stations are given in Tables 4.3, 4.4, and 4.5. The spectroscopic results showed that different groups of polymers were constantly observed at each of the sampling stations. Among these polymers, PET was observed at all three stations, showing the presence of the characteristic C=O stretching vibration with wavenumbers in the range of 1250 to 1015 cm^{-1}. The constant occurrence of these spectral features shows that microplastics are continuously being supplied into the river system as a result of domestic activities. Sources of microplastics at relatively high concentrations can be plastics bottles, plastics food wrappings, and synthetic fibres. Other polymers such as PA, PE, PU, and PS have been detected in moderate amounts and can be contributed to plastics bags, foam products, adhesives, and insulation materials.

Table 4.6 FTIR of Microplastics samples Collected from Station 1

FTIR Peaks	Characteristics	Type of Polymer
3406	O=H Stretching	Polyamide, polyurethane
2920	C=H Stretching	Polyethylene, Polypropylene
2850	C=H Stretching	Polyethylene, Polypropylene
2337	C=C Stretching	Polyethylene
1635	C=C Stretching	Polyamide, polystyrene
1033	C=O Stretching	Polyethylene terephthalate
1215	C=O Stretching	Polyethylene terephthalate
1095	C=O Stretching	Polyethylene terephthalate

Table 4.7 FTIR of Microplastics Samples Collected from Station 2

FTIR Peaks	Characteristics	Type of polymer
3437	O-H Stretcing	Polyamide, polyurethane
3290	O-H Stretching	Polyamide, polyurethane
2360	C=O Stretching	Polyethylene
2920	C-H Strectching	Polyethylene, polyurethane
1639	C=C	Polyamide, polystrene
1087	C-O Stretch	Polyethylene terephthalate
794	C-H	Polystrene
1006	C-O	Polyethylene teraphthalate

Table 4.8 FTIR of Microplastics Samples Collected from Station 3

FTIR Peaks	Characteristics	Type of polymer
3441	O-H Stretching	Polyamide, polyurethane
2399	C=O Stretching	Polyethylene
1033	C-O Stretching	Polyethylene terephthalate
1091	C-O Stretching	Polyethylene terephthalate
914	CH Wag	Poly]vinylchloride
694	Aromatic ring breathing	Polystrene
1168	C-C	Polypropylene
1635	Aromatic C=C	Polyamide, Polycarbonate

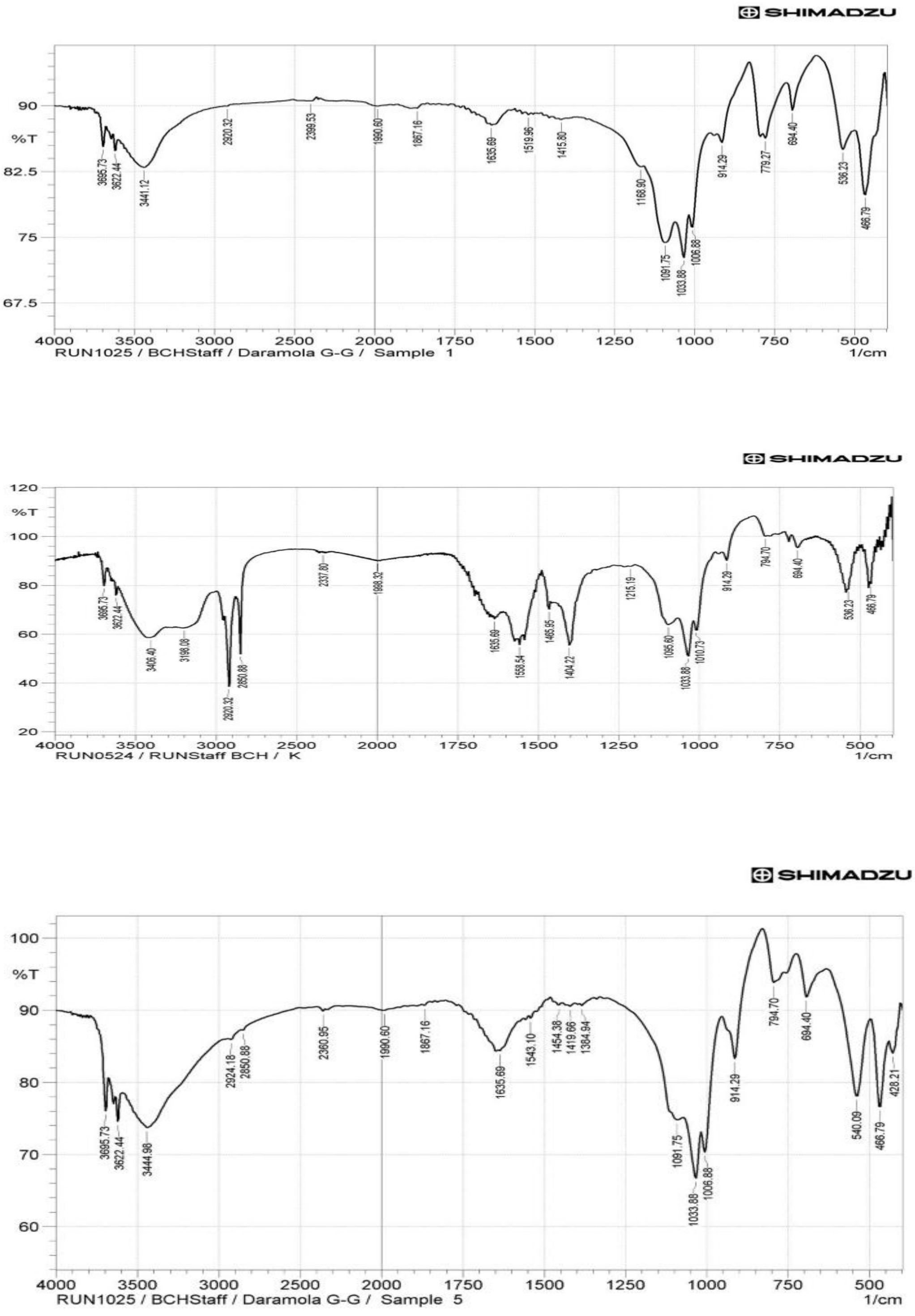

Figure 4.2: Fourier-Transform Infared Spectroscopy Analysis of Microplastic Particles in Water Samples Collected across the Three Stations in Ikpoba River

CHAPTER FIVE

DISCUSSION

5.1 Discussion

This study demonstrates the increasing contamination of plastic pollution in urban centers by the evidences of the occurrence's plastics in Ikpoba River. The predominance of polyethylene terephthalate (PET), polyethylene (PE), and polypropylene (PP) as the major polymers aligns with similar studies in Nigeria and other parts of Africa (Anyaegbu *et al*., 2024; Nduka-Chukwudi *et al*., 2024). PET exhibited the highest mean abundance (24.67%), followed by PA (18.00%) and PP (18.67%), which suggests that single-use plastics mainly plastic bottles, packaging films, and synthetic fibers are the dominant sources of plastic particles are observed in the river. These polymers can persist in aquatic systems for extended periods of time due to their widespread use, great durability, and resistance to environmental deterioration (Andrady, 2017; Hoang, 2022).

Spatial variation in microplastic abundance revealed a progressive increase in concentration from the upstream section of the river toward the downstream area, with Station 3 (Guinness Brewery) recording the highest concentration. This distribution pattern reflects the cumulative influence of anthropogenic activities along the river course, including indiscriminate disposal of plastic waste, runoff from surrounding markets and residential areas, and industrial effluent discharges. The elevated accumulation observed at the downstream station suggests that the hydrodynamic characteristics of the Ikpoba River favour the retention and deposition of microplastics in low-flow regions, which act as sink zones for suspended particles. Denser polymer types such as polyvinyl chloride (PVC) and polycarbonate (PC) are more likely to settle into sediment layers due to their relatively high densities. Similar accumulation trends have previously been reported for the Ikpoba River by Ogbomida *et al.* (2018), confirming the role of the river system in facilitating downstream transport and deposition of plastic pollutants.

The detection of eight polymer types PET, PE, PA, PU, PP, PS, PC, and PVC demonstrates a complex contamination profile consistent with other tropical freshwater systems. Akindele *et al.*, (2019) reported similar compositions in the Awba Reservoir, while Fred-Ahmadu *et al.,* (2024) identified PET, PE, and PP as dominant polymers in aquatic organisms from Southwestern Nigeria. Comparable results were also noted globally: Eriksen *et al.,* (2013) and Fischer *et al.,* (2016) associated the extensive presence of PET and PP with domestic and packaging waste. Their persistence in Ikpoba River shows that these polymers degrade slowly, with PET persists in the environment for over centuries (Ali *et al.,* 2020).

The increasing plastic concentrations from 26.07% at station 1 to 40.35% at station 3 shows a gradual accumulation trend in downstream areas of this river. Similar observation have also been reported by Hurley *et al.* (2018) and Alam *et al.* (2019). We observed high proportions of PVC and PC and it's of no doubt that they would likely come from industrial and municipal wastes. These polymers are commonly used in construction materials, pipes, electrical components, and coatings (Karlsson *et al.*, 2019). Alam *et al.* (2019) recorded similar trends of contamination in the Ciwalengke River, Indonesia. There is a factory beside the river known for releasing effluents contributed significantly to PVC and PC pollution. This suggest that Ikpoba River receives inputs from small industries and residential settlements that release untreated wastewater into the river system and the nature of the river, together with the presence of a Dam, may influence microplastic accumulation downstream.

Compared to other African rivers, the concentration of microplastics recorded in the Ikpoba River falls within the range reported for heavily polluted aquatic environments across the continent. In South Africa, Ferguson *et al.* (2024) reported microplastic concentrations ranging from 12 to 36 particles/L in surface water and debris samples, with polyethylene (PE) and polypropylene (PP) identified as the dominant polymer types. Similarly, Kerubo *et al.* (2021) observed high levels of microplastic contamination in Kenyan coastal waters, where high-density polyethylene (HDPE) accounted for approximately 38.3% of the identified polymers. These similarities in polymer composition and abundance suggest that microplastic pollution in the Ikpoba River is largely associated with the widespread use and improper disposal of disposable plastic materials. The predominance of PE, PP, and related polymers further reflects the continuous input of packaging materials, plastic containers, and domestic wastes into the river system, particularly from urban runoff, market activities, and industrial discharges.

The FTIR analysis indicated that most particles collected were made up of PET, PE, and PP, which are commercial plastics that can be floated easily and retained in suspension in surface water. The floating characteristic of the microplastics makes their ingestion by the aquatic life form much higher (Ogbomida *et al.,* 2023). This finding corresponds to the study conducted by Akindele *et al.* (2020) and Junaid *et al.* (2023), PET and PP are widely used plastics and have observed in the disposal of beverage and food packing materials from urban centers around the region. The variations in polymer oncentrations across the different sampling stations suggests that their distribution within the Ikpoba River is largely influenced by hydrological and physical processes such as water flow, sedimentation, turbulence, and downstream transport. Areas characterized by reduced water velocity may serve as accumulation zones where microplastic particles are retained and deposited within the sediment.

The presence of microplastics in the Ikpoba River represents a serious environmental concern with far-reaching implications for aquatic ecosystems and dependent human populations. Microplastics act as effective carriers of persistent organic pollutants and toxic substances such as phthalate plasticizers, bisphenol A (BPA), and heavy metals, facilitating their adsorption, transport, and eventual bioaccumulation across aquatic food webs (Barboza *et al*., 2018; Katsikantami *et al*., 2020). The detection of polymers such as polyvinyl chloride (PVC) and polycarbonate (PC) further intensifies this concern, as these materials are known to contain hazardous chemical additives capable of leaching into surrounding water bodies. Such contamination can degrade water quality and increase exposure risks for aquatic organisms. Evidence from previous studies indicates that chronic exposure to microplastic-associated pollutants can induce oxidative stress, histopathological alterations, reproductive impairment, and organ dysfunction in aquatic biota (Kalčíková *et al*., 2017; Sussarellu *et al*., 2016).

Ikpoba River is significantly contaminated with microplastic pollution, which may be attributed to household waste, market wastes, and effluents from small-scale industries. The composition of dominant polymer types is related to the consumers' behavior choice and poor waste management practices common in many Nigerian urbanized cities. Overall, these findings underscore the need to improve waste management practices and increase awareness among citizens on how to mitigate microplastic pollution.

5.2 Conclusion

The findings of the present study confirm that the Ikpoba River is contaminated with microplastics arising from both domestic and industrial activities. Several polymer types were identified, including polyethylene terephthalate (PET), polyethylene (PE), and polypropylene (PP), which are commonly associated with single-use plastic products and packaging materials. The predominance of these polymers suggests that indiscriminate disposal of plastic waste and inadequate waste management practices have contributed significantly to the contamination of the river system. The study further revealed an increase in microplastic abundance toward the downstream section of the river, indicating the cumulative effect of urban runoff, industrial effluent discharge, and the downstream transport of plastic debris. This pattern highlights the role of the Ikpoba River not only as an important water resource but also as a receiving environment for urban and industrial wastes. The continuous accumulation of microplastics in the river poses serious ecological concerns, as these particles can be ingested by aquatic organisms, potentially affecting growth, reproduction, and survival. In addition, the transfer of microplastics and associated contaminants through the food chain may present potential health risks to humans who depend on the river for domestic and other purposes.

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APPENDIX

Plate 1.1: Station 1 (Ikpoba Slope)

Plate 2.1: Station 2 (Temboga)

Plate 3.1: Station 3 (Guiness Brewery)